

CLAIMS

What is claimed is:

- 5 1. An exhaust gas recirculation (EGR) system comprising:
 an engine having an intake manifold and an exhaust manifold;
 a turbocharger with at least one compressor stage;
 a first exhaust gas bypass stream connected to receive exhaust gas upstream of the
turbocharger;
10 a first control valve connected in the first exhaust gas bypass stream to control the
amount of exhaust gas received from the exhaust manifold;
 a second exhaust gas bypass stream connected to receive exhaust gas exiting the
exhaust manifold through a turbine section of the turbocharger and combine the gas with an intake
air stream to form an exhaust gas/air mixture that is directed into a first compressor stage of the
15 turbocharger; and
 a second control valve connected within the second exhaust gas bypass stream
upstream of a connection point with the intake air stream for controlling a relative amount of air and
exhaust gas in the exhaust gas/air mixture routed to the first compressor stage of the turbocharger.
- 20 2. The EGR system of claim 1 further comprising an EGR cooler and a second
compressor stage of the turbocharger, wherein the exhaust gas from the first exhaust gas bypass
stream is cooled with the EGR cooler and mixed with the exhaust gas/air mixture to form a final
gas/air mixture before said final gas/air mixture is directed into the second compressor stage of the
turbocharger, and wherein the pressurized final gas/air mixture is introduced into the intake
25 manifold.
3. The EGR system of claim 2 wherein the exhaust gas/air mixture is cooled after it is
compressed by the first compressor stage.

4. The EGR system of claim 2 further comprising a diesel particulate filter to filter exhaust gas in the first exhaust gas bypass stream.

5. The EGR system of claim 1 wherein the pressurized exhaust gas/air mixture exiting a last compressor stage of the turbocharger is combined with the first exhaust gas bypass stream before being introduced into the intake manifold.

6. The EGR system of claim 5 wherein the exhaust gas/air mixture is cooled before entering the last compressor stage.

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7. The EGR system of claim 1 further comprising:

a second turbocharger operated in parallel with the turbocharger;

a bypass for directing a partial flow of exhaust exiting the exhaust manifold into an inlet of a turbine section of the second turbocharger and a first synchronized control valve to control said partial flow; and

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a second synchronized control valve to control a relative amount of exhaust gas/air mixture entering compressor sections of the turbochargers;

wherein exhaust gas exiting the turbine section of the second turbocharger forms a part of the second exhaust gas bypass stream and the pressurized exhaust gas/air mixture exiting the compressor sections of the turbochargers is combined with the first exhaust gas bypass stream before being introduced into the intake manifold.

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8. The EGR system of claim 5 further comprising an EGR cooler to cool the first exhaust gas bypass stream.

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9. The EGR system of claim 1 further comprising an EGR cooler to cool the second exhaust gas bypass stream.

10. The EGR system of claim 1 further comprising a charge air cooler to cool the pressurized exhaust gas and air before they are introduced into the intake manifold.

11. The EGR system of claim 1 further comprising at least one exhaust after-treatment
5 to treat the second exhaust gas bypass stream.

12. An EGR system comprising:
an engine having an intake manifold and an exhaust manifold;
a pair of serially arranged turbochargers;
10 a first exhaust gas bypass stream connected to receive exhaust gas upstream of a first turbocharger;
a first control valve connected in the first exhaust gas bypass stream to control the amount of exhaust gas received from the exhaust manifold;
a second exhaust gas bypass stream connected to receive exhaust gas exiting the
15 exhaust manifold through a turbine section of at least one turbocharger and combine the gas with an intake air stream to form an exhaust gas/air mixture that is directed into a compressor section of the second turbocharger; and
a second control valve connected within the second exhaust gas bypass stream upstream of a connection point with the intake air stream for controlling a relative amount of air and
20 exhaust gas in the exhaust gas/air mixture routed to the compressor section of the second turbocharger;
wherein the pressurized exhaust gas/air mixture exiting the second turbocharger is directed to an inlet of a compressor section of the first turbocharger for further compression.

25 13. The EGR system of claim 12 wherein a turbine section of the second turbocharger receives exhaust gas exiting a turbine section of the first turbocharger and the second exhaust gas bypass stream is connected to receive exhaust gas exiting the turbine section of the second turbocharger.

14. The EGR system of claim 13 wherein the exhaust gas from the first exhaust gas bypass stream is cooled and mixed with the exhaust gas/air mixture before said mixture is directed to an inlet of a compressor section of the first turbocharger to form a final gas/air mixture, and wherein the pressurized final gas/air mixture exiting the compressor section of the first turbocharger is introduced into the intake manifold.

15. The EGR system of claim 14 further comprising a diesel particulate filter to filter exhaust gas in the first exhaust gas bypass stream.

16. The EGR system of claim 13 wherein the pressurized exhaust gas/air mixture exiting the compressor section of the first turbocharger is combined with the first exhaust gas bypass stream before being introduced into the intake manifold.

17. The EGR system of claim 16 further comprising an EGR cooler to cool the first exhaust gas bypass stream.

18. The EGR system of claim 12 wherein the second exhaust gas bypass stream is connected to receive exhaust gas exiting a turbine section of the first turbocharger.

19. The EGR system of claim 18 wherein the exhaust gas from the first exhaust gas bypass stream is cooled and mixed with the exhaust gas/air mixture before said mixture is directed to a compressor section of the first turbocharger to form a final gas/air mixture, and wherein the pressurized final gas/air mixture exiting the compressor section of the first turbocharger is introduced into the intake manifold.

20. The EGR system of claim 18 further comprising a diesel particulate filter to filter exhaust gas in the first exhaust gas bypass stream.

21. The EGR system of claim 12 further comprising a charge air cooler to cool the exhaust gas and air before they are introduced into the intake manifold.

22. The EGR system of claim 12 further comprising an EGR cooler to cool the second
5 exhaust gas bypass stream.

23. The EGR system of claim 12 further comprising at least one exhaust after-treatment to treat the second exhaust gas bypass stream.

10 24. The EGR system of claim 12 wherein the exhaust gas/air mixture is cooled after it is compressed by the compressor section of the second turbocharger.

25. An EGR system comprising:
an engine having an intake manifold and an exhaust manifold;
15 two turbochargers;
an exhaust gas bypass stream;
a control valve connected in the exhaust gas bypass stream to control the amount of exhaust gas received from the exhaust manifold; and
a cooler to cool the exhaust gas;
20 wherein said exhaust gas is mixed with intake air to form an exhaust gas/air mixture and the exhaust gas/air mixture is compressed by a compressor section of the first turbocharger before being directed to the intake manifold.

26. The EGR system of claim 25 wherein the exhaust gas bypass stream is configured
25 to receive exhaust gas downstream of a turbine section of the first turbocharger.

27. The EGR system of claim 26 wherein the exhaust gas/air mixture is compressed by a compressor section of the second turbocharger before being compressed by the compressor section of the first turbocharger.

28. The EGR system of claim 26 wherein the intake air is compressed by a compressor section of the second turbocharger before it is mixed with the exhaust gas.

5 29. The EGR system of claim 28 wherein the intake air is cooled after it is compressed by the compressor section of the second turbocharger.

30. The EGR system of claim 25 wherein the exhaust gas bypass stream is configured to receive exhaust gas upstream of the turbochargers.

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31. The EGR system of claim 30 wherein the intake air is compressed by a compressor section of the second turbocharger before it is mixed with the exhaust gas.

15 32. The EGR system of claim 31 wherein the intake air is cooled after it is compressed by the compressor section of the second turbocharger.

33. The EGR system of claim 25 further comprising a diesel particulate filter upstream of the control valve.

20 34. The EGR system of claim 25 further comprising a charge air cooler to cool the pressurized exhaust gas/air mixture before it is introduced into the intake manifold.